Example 1: Hematological Analyses

Referring to FIG.4, to enable an analysis of white blood cells (WBC's) within an anticoagulated whole blood sample, a container 18 having approximately 0.8 micrograms (μg) of a sensible colorant and 50 μl of anticoagulated whole blood disposed within its reservoir 22 is inserted into the Sample Transport Module 14. Prior to insertion, the operator may gently shake the container 18 to ensure uniform mixing of the colorant and the fluid sample. The label reader 38 disposed within the Reader Module 14 reads the container label 28 and transfers the information contained within the label 28 to the Programmable Analyzer 16. In this example, the information identifies one or more specific analysis algorithms to be used and a plurality of container features operable to enable the analysis of the biologic fluid sample. Those features include identifying the anticoagulating agent as EDTA, the sensible colorant as a fluorescent highlighting supravital stain such as acridine orange (or basic orange-21 or the like), and physical characteristics of the container chamber 20 and the ~~coordinate addresses~~spatial locations of those physical characteristics within the chamber 20. For this particular analysis, only the second wall 32 of the container chamber 20 need be transparent since a fluorescent stain is being used. In all cases, it is the features of the container 18 and the capabilities of the apparatus 10 to utilize those features that enables the apparatus 10 to perform a plurality of tests on a single sample.

Referring to FIGS. 3 and 4, the Programmable Analyzer 16 next directs the rod 90 within the Reader Module 12 to actuate the valve 26 within the container 18 and thereby release the sample and colorant mixture into the chamber 20. Once the sample is distributed within the chamber 20, the sample resides quiescently during the analysis. The only sample motion within the chamber 20 will possibly be Brownian motion of the sample's formed constituents, and that motion is non-disabling for the present invention. Using the information provided through the container label 28, the analysis algorithm directs the positioner 86 to move the container 18 to a position where the field illuminator 40 is aligned with a first region of the chamber 20, and in particular with one of a plurality of fields having a

through-plane thickness 78 of approximately twenty microns. The intra-chamber spatial location ~~coordinate address~~ of each of these fields is known and communicated to the Programmable Analyzer 16 through the label 28. The chamber through-plane thickness 78 of approximately twenty microns is chosen for a couple of reasons. First, an evaluation volume of 0.02μl, (formed by a particular sample field having a cross-sectional area of one millimeter (mm) and a through-plane thickness 78 of twenty microns) typically contains 50-200 WBC's which is a favorable quantity for evaluative purposes. The cross-sectional area referred to is the area of the sample imaged by the field illuminator 40 as described above. Second, a through-plane thickness 78 of twenty microns provides an optimal chamber 20 for rouleaux and lacunae formation.

If the sample is imaged by the apparatus 10 immediately after the sample has been inserted into the chamber 20, the sample will appear opaque when examined with the epi-illuminated fluorescence and will not be favorable for analysis. The opaque appearance is caused by the red blood cells (RBC's), which form an overlapping mass prior to the formation of the rouleaux. To avoid an undesirable opaque image, the analysis algorithm stored within the Programmable Analyzer 16 provides a timing function wherein operation of the field illuminator 40 is delayed for a period of approximately thirty (30) seconds after the sample has been introduced into the chamber 20. During that time, the Programmable Analyzer 16 may position the appropriate SE or LSE filters 58,66 if any, within the path of the light beam 54 within the field illuminator 40. After the delay, light selectively produced from the light source 44 and filtered within the field illuminator 40 is directed into a sample field within the chamber 20. The light passing into the sample causes the colorant within the sample to fluoresce and emit light of a particular wavelength. The emitted light then passes through the field illuminator 40 and into the image dissector 42 where it is converted into an electronic format in real time.

The electronic format of the emitted image, which can be shown real-time on the monitor 102, will show that after lying substantially motionless for approximately thirty (30)

seconds within the chamber 20, the RBC's will have spontaneously clustered into a plurality of rouleaux separated by lacunae. It is in the lacunae where whole blood sample constituents other than RBC's (e.g., WBC's and platelets) can be found and evaluated. Using 0.02μl sample fields keeps the number of WBC's in each field reasonable (a normal whole blood sample contains approximately 7,000 WBC's per μl of sample; a 0.02μl sample of normal whole blood contains approximately 140 WBC's). A number of fields within the first region are evaluated until a statistically sufficient number of cells are counted, which in practice is approximately 1000 cells.

Referring to FIGS. 1 and 4, in the event it is determined through the analysis algorithm that the sample WBC population within the fields of the first region is too low to obtain statistically accurate information, the Programmable Analyzer 16 directs the Reader Module 12 to perform the evaluation process again, this time in a second region of the chamber 20 having a plurality of fields with a through-plane thickness 78 slightly larger than twenty microns. The larger volume of the fields within the second region are more apt to have a sample with a statistically acceptable population of WBC's. Likewise, if the WBC population within the sample is too high to obtain statistically accurate information from the fields within the first region of the chamber 20, the Programmable Analyzer 16 directs the Reader Module 12 to perform the evaluation process again, this time in a third region of the chamber 20 having a plurality of fields with a through-plane thickness 78 slightly smaller than twenty microns and consequent lesser volume. In either case, the intra-chamber spatial locations ~~coordinate addresses~~ of the fields in either region are known and communicated to the Programmable Analyzer 16 through the label 28. The above described iterative process for finding a region possessing an optimum number of constituent WBC's within the substantially undiluted anticoagulated whole blood sample is an example of the apparatus's capacity to produce optimum results for a given analysis.

If additional WBC information is sought, the WBC's (lymphocytes, granulocytes, monocytes, etc.) can be analyzed within the sample using the image dissector 42 of the Reader